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University of Cambridge
School of Agriculture Memoirs

Memoir No. 31

A summary of the papers published by the members of the Staff of the School of Agriculture and its Associated Research Organisations during the period Oct. 1st, 1958—Sept. 30th, 1959

Review Series

No. 14.

Statistics—a Retrospect

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FOREWORD

This Memoir, which is published under the general editorship of the Librarian of the School, represents an attempt to present as succinctly as possible by means of author summaries the contributions made by members of the Staff of the School of Agriculture and its Associated Research Organisations to the development and progress of Agricultural Science, to indicate to research workers interested the Journals in which the full papers are presented and to act as a complete record of papers published.

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Statistics — a Retrospect*

by R. C. CAMPBELL, Ph.D.

University Lecturer in Statistics in the Faculty of Agriculture

The history of the teaching and application of statistical methods in the School of Agriculture is essentially the story of the work of two men, George Udny Yule and John Wishart. Between them they covered a period of 44 years, at the start of which Pearsonian statistics was still something of a novelty and at the end of which Fisherian biometry was an accepted necessity for accurate experimentation.

The beginnings, however, are to be found before Yule's appointment. Professor T. B. Wood was one of the first to use explicit measures of variability, and was co-author of the first School paper on statistical methods. In 1905 he used half the range as a measure of error (Wood & Berry, 1905) and in 1910 he used the probable error of the mean (Wood, 1910); both these measures are proportional to the standard deviation, although in the case of the former the constant of proportionality is a function of the sample size. Also in 1910 he published with F. J. M. Stratton (now Professor) a paper on "The interpretation of experimental results", beginning with the assertion "The interpretation of experimental results of any kind requires considerable caution, and this is more than ordinarily necessary in the case of agricultural experiments" (Wood & Stratton, 1910). Both authors were Fellows of Gonville and Caius, and the collaboration of an agriculturalist and an astronomer illustrates well the fruitful working of the college system at its best.

The paper reads almost as a present-day introductory discussion; the authors postulate two requirements in the interpretation of results, that "the best value of the several determinations must first be found" and that the experimenter "must have a definite idea of the degree of accuracy of his method". They emphasise the importance of examining the form of the frequency curve and the danger of averaging heterogeneous results, both precautions which many workers still fail to observe. They use the probable error as the measure of variation, giving the frequency interpretation of it and selecting multiples of the probable error required for "significance" on the basis of the probabilities they represent; the concept of the null hypothesis is implicit in their argument. They are aware of the need for tests of goodness of fit but the χ^2 test is not mentioned. They emphasise that the increase of precision requires replication and that the control of conditions is not enough. The paper contains the elements of many important developments in biometry and Fisher himself has paid tribute to its historical importance.

After the publication of this paper there were discussions on the teaching of statistics and early in 1912 the Board of Agricultural Studies and the Special Board for Economics and Politics jointly recommended the creation of a University Lectureship in Statistics. When this recommendation was made public there was a certain amount of opposition and in Discussion several speakers attacked the proposal, one referring to the unsuitability of "mere statistics" as a university subject and maintaining that "we are all statisticians"; one of the most persuasive speakers in favour was J. M. Keynes (*Reporter*, 1911–12, pp. 1138–41). The Grace giving effect to the proposal was approved on 6 June, 1912, and on 8 June, Yule was appointed for five years from 1 October.

†Yule came to Cambridge at the age of 41 as a man already of high repute in the world of statistics. In 1893, when 22, he had been appointed a demonstrator at University College under Karl Pearson, who was then beginning his work on statistics and quickly drew Yule into the subject. Yule left University College in 1899 but returned in 1902 to give evening lectures as Newmarch Lecturer in Statistics. He gave these lectures until 1909 and used them as the basis

* *This is the fourteenth of a series of articles summarising phases of agricultural research particularly associated with the School of Agriculture since its inception, previous contributions having dealt with:—Physiology of Reproduction, Plant Virus Research, Plant Breeding, Animal Nutrition, Horticulture, Agricultural Economics, Field Drainage, Animal Production, the Cambridge University Farm, Crop Husbandry, Agricultural Teaching, Entomology and Nematology, and Poultry Genetics. Further contributions on other work will appear in future issues.*

† *Much of the information in the succeeding paragraphs is obtained from the obituaries by Yates* (1952) *and Kendall* (1952).

of his book *An Introduction to the Theory of Statistics* (Yule, 1911). His work in this time was concerned mainly with correlation, regression and measures of association. He became a Fellow of the Royal Statistical Society in 1895, and an Honorary Secretary in 1907, holding this onerous post until 1919.

In Cambridge he lectured on Elements of Statistical Method for the Special Board of Economics and Politics and on Statistical Methods in Agricultural Research for the Board of Agricultural Studies; this latter course consisted of one lecture a week in the Lent term. After the interruption of the war this course was resumed in 1919–20, now covering the Michaelmas and Lent terms; in this year he also began a joint course with Professor Biffen called at first Botany and later Genetics. In the Lent term, 1923, he began a Special Course for the Diploma in Agriculture, Part I, consisting of two lectures and a practical class each week. In 1926 this course was extended into the Easter term. Throughout this time his lectures in Economics continued, his more mathematical lectures being given in that faculty. In 1931, when only 60, he resigned his Lectureship, finding his considerable burden of teaching in an increasingly mathematical subject too much to be borne longer. When he made it known that he intended to retire, the plans which were in hand for the creation of a Readership in Statistics were expedited so that he might hold the Readership at least for a few months, from 1 January, 1931, until his resignation took effect on 30 September.

During his time in Cambridge Yule did some of his best work, the most notable papers dealing with the study of time-series. He was elected a Fellow of the Royal Society in 1922, and from 1924 to 1926 was President of the Royal Statistical Society. Of this period he wrote that his connection with the School of Agriculture "was a very happy association for me—I liked the agricultural work best of all, and liked the men". He continued to do some teaching as College Lecturer until 1940 and in the latter part of this time returned to the philological interests of his forbears, publishing several papers and a book on *The Statistical Study of Literary Vocabulary* (Yule, 1944). He died on June 26, 1951, after two and a half years in nursing homes suffering increasingly from heart troubles.

It is interesting to consider how far Yule was successful in spreading the concepts of statistical analyses among those with whom he worked. He published various papers on agricultural and biological subjects, several of them written jointly with members of the School (Yule, 1914, 1915, 1923, 1924; Engledow & Yule, 1914; Wood & Yule, 1914). In one of these papers he introduced the use of minimum χ^2 for the estimation of linkage, but he did not succeed in evaluating the variance of the estimate (Engledow & Yule, 1914). Immediately after the war he gave considerable advice and assistance to the National Institute of Agricultural Botany in the layout and analysis of their extensive variety trials, and later, drawing on this experience, he wrote with Engledow a pamphlet on *The Principles and Practice of Yield Trials*, setting out the basic ideas of statistics in so far as they applied to agricultural experiments (Engledow & Yule, 1926). This pamphlet contained a great deal of statistical good sense but was in some respects outdated when it was written for it took no cognizance of the new ideas Fisher was developing. Thus although *Statistical Methods for Research Workers* appeared in the same year, and the ideas of analysis of variance had already been published in journals, Yule makes no reference to this technique and moreover gives a biased estimate for the residual mean square in a randomised block layout. This was an unfortunate omission in view of Yule's statistical standing, but it is clear that he himself appreciated how far Fisher's methods were in advance of those already in use; when Pearson died in 1936 Yule wrote to Kendall "I feel as though the Karlovingian era has come to an end, and the Piscatorial era which succeeds it is one in which I can play no part" (Kendall, 1952).

These papers of Yule's, particularly those with members of the School, set a useful example of the applicability of statistical methods to agricultural experiments, but this example was not followed to any great extent by many workers in the School. This is well seen in the papers published in those years; workers of very considerable standing and experience carried through programmes of research in which they interpreted lengthy numerical results without any appeal to statistical techniques. Some examples are quite remarkable; a paper written in 1923 on "The determination of the number of bacteria in soil" contains no statistical methods beyond the use of the standard deviation, although both "Student" and Fisher had already published papers on the Poisson distribution (Fisher, Thornton & McKenzie, 1922; "Student", 1907, 1919). A paper in 1927 on

"Seasonal variations in the productivity, botanical and chemical composition, and nutritive value of pasturage on a heavy clay soil" does not contain any measure of variation at all. Many papers involved what would now be called tests of goodness of fit, but in no case was any use made of the χ^2 distribution although Pearson had rediscovered this many years before (Pearson, 1900). Not only were omissions of technique very common, but major errors of statistical logic were frequent; a recurring example of such an error was the carrying out of accurate chemical determinations on one animal without any apparent realisation that unless the experiment was repeated on different animals the results obtained could well apply only to the one animal tested.

Nevertheless there were some real steps forward. Engledow (1926) introduced the idea of a sample census of a crop of corn, and applied this idea in later studies; the sample was chosen to represent all parts of the area studied and although by present standards it would have been improved by a degree of randomness the concept was of real value. Moreover many papers show a robust appreciation of practical good sense which should always delight the biometrician. In the paper just cited Engledow wrote "For the analysis of yield under field conditions, there must be studies of growth under field conditions". Wood & Capstick (1928) wrote "Finally the writers claim that results worked out . . . from records of large numbers of animals kept under normal conditions might be expected to possess a wider practical value than similar results obtained from more refined and accurate experiments on single animals under laboratory conditions". Sanders (1927*a*, *b*, 1928*a*, *b*) in a series of papers on "The variations in milk yields caused by season of the year, service, age and dry period, and their elimination" discussed means of "correcting" for the effects of these variables, but was always very careful to check that the corrections he used were realistic and reasonable and not mere statistical tricks; this very necessary caution was in some danger of being forgotten when corrections by covariance later became fashionable.

All in all, Yule's tenure saw very considerable progress in the application of his subject. He had the difficult task of introducing new, and in some ways unattractive, ideas into an existing community of workers, and if he were not in every respect successful, nevertheless he left behind an attitude of mind receptive to the new techniques his successor was to introduce. Moreover, the quantitative way of thought to which his lectures introduced many generations of students had a great effect in spreading the knowledge and acceptance of statistical concepts.

*Wishart came to Cambridge when he was nearly 33. He had read mathematics at Edinburgh and had worked for three years under Pearson and for three and a half years under Fisher at Rothamsted; he was thus well trained in both the old and the new schools of statistics. During his time at Rothamsted he had derived the generalised product-moment distribution which now bears his name (Wishart, 1928); this derivation illustrated one of his major interests in later years, multivariate analysis.

In the years following his appointment he undertook a considerable amount of teaching. In the School of Agriculture he gave a course of eight lectures in the Michaelmas term on Field Experimentation, and attendance at this course was required of all Diploma students—the same had been true in the latter years of Yule's tenure. He also lectured on statistics in the Lent and Easter terms, giving two lectures a week; these courses were required for certain sections of the Diploma, such as Economics and Genetics. Also in the Lent and Easter terms he gave lectures in the Faculty of Mathematics on the Mathematical Theory of Statistics; these courses, which came within Schedule B of the Mathematics Tripos, were the first lectures in statistics to be given to mathematicians. This innovation set the pattern for one of the major problems of the latter part of Wishart's tenure, the relationship between the producers and the consumers of statistical theory, the mathematicians and the experimental scientists. This heavy burden of lecturing continued with very little variation until 1938 when M. S. Bartlett (now Professor), who had been one of Wishart's students, was appointed University Lecturer in Mathematics.

The examination policy of the School with regard to statistics developed considerably during this time. Occasional questions on statistics had appeared in the Diploma examinations at least since 1925, when one was set in a soil science paper; I have not been able to trace any earlier papers. These questions were usually optional. In 1933 the subject Applied Statistics was added to the list of options for the Diploma in Agricultural Science, and since that time there

* *Much of this information is taken from the obituary by Pearson* (1957).

has always been in the School the possibility of taking statistics as a major subject at the post-graduate level.

In this pre-war period Wishart not only undertook the teaching already discussed but also put much effort into improving the statistical quality of the School's experimental work. In opening a discussion of the Industrial and Agricultural Research Section of the Royal Statistical Society in November, 1938, he gave an interesting account of the joint study he had undertaken with Woodman, Evans and Callow of the experimental and statistical techniques appropriate to nutrition experiments with pigs (Wishart, 1938, 1939*a*, Woodman *et al.*, 1936). This joint attack on a practical problem is illustrative of the best relationship between the statistician and the laboratory and field worker. Another paper of the same period dealt with the interrelations of litter size, duration of pregnancy and birth weight in rabbits (Wishart & Hammond, 1933). Wishart also produced a pamphlet on *Field Trials; their Layout and Statistical Analysis* (Wishart, 1940), and, following in the tradition established by Engledow and Yule, wrote with Sanders *The Principles and Practice of Field Experimentation* (Wishart & Sanders, 1935). He also found time for a visit to Nanking in 1934 to read a paper to the plant breeding conference held there.

After the war Wishart returned to Cambridge with some hesitancy; a great deal of work in developing the teaching of statistics was still to do, and the conflict between mathematics and experimental science was unresolved. On the mathematical side there was, however, immediate progress; on 17 June, 1947, the University approved the institution of the Diploma in Mathematical Statistics, and in 1949 the Statistical Laboratory was opened under the aegis of the Faculty of Mathematics. This Diploma is primarily a mathematical course, but the student is required to apply his theory in a selected field; one possible field is Agriculture. This form of course, which has been followed at other universities, is the most successful attempt to date to develop in mathematicians that feeling for experimental science which is the essential prerequisite of statistical practice.

Whilst these developments were taking place in mathematical teaching, the courses in the School of Agriculture continued much as before. The revision of the Diploma regulations in 1945 left Statistics as one of the five sections of the Diploma in Agricultural Science, and the courses in Field Experimentation were still required for all Diploma students. Parts of these courses were given either by Wishart or by lecturers from the Statistical Laboratory and, continuing pre-war practice, parts were given by members of the School. The full set of courses was required only for Section D candidates but in fact quite a number of students from other sections attended all the lectures; the level reached in the full course was quite high, including some discussion of the more sophisticated experimental designs and of elementary multivariate analysis.

Whilst these developments were taking place Wishart continued his own work. He wrote a series of expository articles for the *Journal of the Institute of Actuaries Students' Society*, occasioned by the increased statistical content of the Institute's examination syllabus (Wishart, 1947*a*, *b*, *c*, 1948*a*, 1951). He prepared a pamphlet on covariance analysis (Wishart, 1950) and also a new edition of his book with Sanders (1955). He was first Chairman of the Research Section of the Royal Statistical Society and took a leading part in the Society's two post-war committees on the Teaching of Statistics—a subject which had long interested him (Wishart, 1939*b*, 1948*b*, 1955). In 1949 he lectured at the Universities of North Carolina and California, and in 1954 he taught at the F.A.O.'s Training Centre in Experimental Design and the Survey Technique of Experimentation held in New Delhi. In July, 1956, he was on holiday from a similar course in Mexico City when he died suddenly while bathing at Acapulco on the Pacific coast.

The gap which his death left in the statistical community in Cambridge was very considerable. He had been able to provide a personal link with the formative years of modern biometry and had seen, and taken a hand in guiding, many of the developments which we now accept as essential features of Cambridge statistical life. He was never afraid to express his opinions, and his direct approach to a problem was most refreshing. I personally have much for which to be grateful to him, for he guided and directed my first interest in statistics, and the lectures he gave in the Faculty of Mathematics largely influenced my choice of that career.

After his death the question of the relationship between mathematical statistics and the experimental sciences, which had been temporarily answered by his move to the Statistical Laboratory, was reopened and the General Board began a review of the organisation of the teaching of statistics in the University. Before this review was completed, however, the Board recommended the

appointment of a University Lecturer in Statistics in the Department of Agriculture (*Reporter*, 1956–57, p. 1014); this recommendation was approved and the present lecturer took office in October, 1957. With this appointment the statistical complement of the School was increased to its present figure of two University Lecturers—one in Statistics and one in Field Experimentation—with assistance from one University Demonstrator and one Farm Demonstrator; five lecture courses are now given, with the necessary associated practical classes. The content of these courses has continued much as it was in Wishart's lifetime.

Whilst these increases in staff have mainly affected the teaching side of the School's work another development which has taken place in the past few years has had some bearing on the research side. This development is the growth of the A.R.C. Statistics Group which, after an initial period of attachment to the Units of Animal Reproduction and Reproductive Physiology and Biochemistry, was on 1 January, 1956, constituted a separate entity professionally responsible to Dr F. Yates. The services of this Group have always been freely available to the School, and have proved of considerable benefit in terms both of experience in analytical and experimental techniques and of computational facilities. This close association may be expected to continue in the future.

In considering the forms which future developments are likely to take, the two main problems are the relationships of biometry with mathematical statistics and of the statistician with the experimental scientist. Both these problems have been with us for a long time—almost as long as statistics itself—and neither is likely to be solved completely in the near future; nevertheless they affect so intimately the work of the biometrician that their solution must continually be attempted. The brief discussion of these problems which follows is, of course, solely a statement of the writer's personal opinions.

The first problem, the relation of biometry to mathematical statistics, has been accentuated by the struggle Wishart had to get statistics recognised as mathematically respectable. That battle is largely over and the University has a flourishing group of mathematical statisticians. But the very increase in the mathematical stature of statistics means that it is becoming increasingly difficult to produce within the limits of an orthodox university course a man who is well qualified both mathematically and in an applied science, and the possession of good qualifications in both these fields is essential to the practising statistician. At the moment, the course for the Diploma in Mathematical Statistics faces this problem by taking students who have obtained satisfactory Honours in Part II of the Mathematics Tripos and who can therefore appreciate an intensive mathematical course to which is added only an introduction to some applied field. This relative imbalance between mathematics and application is satisfactory because most people taking the course go to established statistical units and learn there the details of their applied field. In the School, however, we cannot accept this solution because many of our students go overseas to posts where expert guidance in the application of statistics is not readily available; it is therefore doubtful whether a degree in mathematics is an entirely suitable qualification for Section D candidates—and indeed if it were we should be in some danger of merely duplicating the Diploma in Mathematical Statistics. The only exception to this conclusion would appear to be students coming to Agriculture after taking Part II of the Mathematics Tripos in their second year and able therefore to spend two years on Section D; such students are not likely to be very common. This being so it appears that in the future Section D candidates will usually possess a degree in Agriculture, possibly having done a very little biometry in that course. Such candidates clearly could not attempt the mathematical courses required for the Diploma in Mathematical Statistics, which present Section D candidates attend, and would require to be taught their biometry entirely within the School. A man passing this version of Section D would not be qualified as a practising statistician, but he would be a useful member of a research station's staff and should at least know when he was in need of advice from a professional statistician.

The question of the best form of relationship between the biometrician and the experimental worker has in the past caused a good deal of argument, but there are indications that it is now becoming slightly less vexed a problem. In the early days the biometrician was an outsider to be approached only when strictly necessary. Several papers in the 1920's acknowledge Yule's help with "the purely statistical aspects of the work"; in Wishart's paper with Woodman *et al.*, the statistical contribution is carefully divided from the rest (Woodman *et al.*, 1936). Present-day thinking, on the other hand, regards the biometrician as an equal co-worker, and requires his

collaboration at all stages of an investigation; the essential requirement of this concept is that the biometrician must take a genuine interest in the biology as well as in the numbers it produces, and must understand the logical significance of the investigation. This has always been one of the central points of Fisher's approach.

This change of attitude towards the biometrician has arisen partly from trial and error on the part of the experimentalist, and partly from the increasing complexity of statistical techniques; it is now rare for a laboratory worker to be able honestly to claim that he is his own statistician. This is true not only of the techniques required but also of the sheer labour of the computations; the advent of automatic calculators is materially changing accepted ideas of what is a reasonable analysis in a problem, and this in turn emphasises the experimentalist's need of advice and assistance in the processing of his results. The School is fortunate to have access, via the A.R.C. Statistics Group, to the calculator at Rothamsted; the usefulness of this service is continually increasing.

These problems are merely the most recent in the development of statistical work in the School of Agriculture; the account in the earlier part of this article of the progress made under the guidance of Yule and Wishart gives every reason for confidence that present problems, like those of the past, are no more than incidents in a long and fruitful process of development.

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AGRICULTURAL ECONOMICS

BARNARD, C. S. & SMITH, V. E.

Resource Allocation on an East Anglian Dairy Farm—A Study in the Application of Linear Programming. Pp. 22. *Fm Econ. Br. Occ. Pap. No.* 6, 1959. Price 2s. 6d. Post Free.

Much of the increase in farm output in recent years has been due to technological advance, both in the realm of better crop varieties and of improved methods of production. To a lesser extent it has been due to a re-arrangement of the cropping and stocking of farms.

This study is concerned with the latter, and perhaps more neglected, aspect of farm planning. Given a certain level of technical expertise, what are the opportunities for raising farm output and profit solely by a re-distribution of farm resources among the enterprises that compete for their use?

In seeking an answer, an 84-acre Suffolk arable-dairy farm typical of many others is analysed, using the Simplex procedure of linear programming. This is an application of matrix algebra which lends itself to the solution of problems of a maximisation or minimisation type, and may be usefully handled on electronic computors. The problem is set up in terms of (1) the limitations imposed by available resources and other restrictions on the activities that may be carried; (2) the requirements of activities for resources and their responses to them (input/output data), and (3) the cost of inputs and the price of outputs.

The solution suggested is a simultaneous expansion of cash crops (wheat, barley, peas and sugar-beet) by 9 acres (25 per cent.) and of the dairy herd by 2 cows (13 per cent.). The acreage required is obtained by ceasing to grow oats and beans for the dairy herd and instead purchasing their equivalent. Farm output rises by 16 per cent., from £4045 to £4680, and farm profit by 25 per cent., from £797 to £998.

BRIGGS, M. & JORDAN, P.

Textbook of Economics. 7th ed. Revised by R. A. Mackness. Pp. iv + 583. (Univ. Tutorial Press, London, 1959. Price 18s.)

GRAVES, P. E. & WALLACE, D. B.

Report on Farming 1957–58.

Fm Econ. Br. Rep. No. 48. Price 3s. 6d. Post Free.

This report covers the financial changes on an identical sample of 320 farms in the Eastern Counties for the harvests of 1956 and 1957. The first chapter contains notes on the changing rewards to tenants and landlords since the 1930's and on the fluctuation in farm profits between types of farms. The second chapter deals extensively with the changes in the accounts of the 320 farms. The average farm income fell by £109 per farm, due mainly to a rise in costs rather than fall in receipts. There were wide differences between districts, however, and the alluvial areas of the fens and silts made substantial gains. The changes in both costs and returns are examined in detail. The final chapter is devoted, as usual, to efficiency standards against which farmers may compare their own results, and a full description is given of the method of analysis used.

MACKNESS, R. A.

Economics of Rearing and Fattening. Pp. 50–57. Contr. to *Beef Production.* Bull. No. 178, Minist. Agric., London, 1959. Price 5s.

NIX, J. S.

Economics of Producing Sugar Beet, 1957.

Fm Econ. Br. Mimeogr. Rep. No. 55, 1958. Price 2s. Post Free.

The average cost of producing sugar beet on 100 farms situated on heavy, light, fen and silt soils in 1957 was £62 an acre, ranging from £57 in West Norfolk to £68 in Holland, Lincs. Owing mainly to a spring drought, yields—and therefore profits—were relatively low, especially in South Cambs. and North Essex/South-West Suffolk, where losses averaging £14 and £17 an acre respectively were made.

The report discusses the reasons for cost variation between areas and farms. With costs of £65 an acre in a "normal" year, a yield of 12–13 tons (depending on the sugar content and the use made of the tops) is needed to give a reasonable profit of £15 an acre.

Labour requirements averaged 145 man-hours an acre with hand harvesting and 105 with mechanical harvesting. The report describes how requirements can vary from 40 to over 200 man-hours an acre. The economic implications of mechanical thinning and harvesting are discussed in detail.

1503* Nix, J. S.

Labour Requirements for Sugar Beet.

Agriculture, Lond. 1959, **65,** 549–53.

Average labour requirements for sugar beet have fallen from 235 man-hours an acre for a light crop in 1927–28 to 115 in 1957. Requirements on individual farms range from 65 to nearly 300 man-hours. Considerable reductions—down to 40 man-hours an acre—can be made by making the maximum use of machinery. The largest potential savings are in thinning and harvesting, which would justify mechanisation on a farm with as little as 8–10 acres of sugar beet, even if yields are lowered by a ton an acre, provided the saving in labour-hours is effectively translated into a saving in labour costs.

Sturrock, F. G.

La Progettazione di Stalle Aperte.

Informatore Zootecnico. 1956, **6** (14), 211–16.

A discussion of methods of designing livestock buildings—particularly cattle yards.

Sturrock, F. G.

Some Comments on the Role of Agricultural Economics in the Sudan. Pp. 9 + Appendix. December, 1958.

A suggested programme of research prepared at the request of the Sudanese Ministry of Agriculture for their newly established department of agricultural economics.

The report covers the following points:

1. The objectives of such a programme, as an aid to farm policy, advisory work and training.
2. The research methods that might be used.
3. The operation of such a department and liaison with other departments.

In the appendix, data from one of the recently settled mechanised grain farms are given to show how such information could be used for advisory purposes. Comments are given on how surveys could be carried out in the Gezira cotton scheme, on pump irrigated farms along the Nile and on fruit and horticultural holdings.

Wallace, D. B.

Farm Accounts and How to Use Them. Pp. 32.

(Farmer and Stock-breeder Publ., London, 1959. Price 2s. 6d.)

A description of a single method of keeping and analysing farm accounts for management purposes, together with a brief outline of certain records necessary for checking the efficiency of individual enterprises.

Wallace, D. B. & Plaister, A. J.

Apple Production.

Fm Econ. Br. Mimeogr. Rep. No. 56, 1958. Price 2s. 6d. Post Free.

This study covers the cost of growing both dessert and cooking apples in the Eastern counties. An appreciation of the future trend in apple production is made at the beginning.

A model of the costs of production is constructed, divided into the following headings:

1. Fixed costs of establishment.
2. Fixed annual costs, e.g. spraying, pruning, etc.
3. Variable costs of production, e.g. picking.
4. Fixed costs of storage, grading and packing.
5. Variable costs of storage, grading and packing.

From this data, a formula was produced to predict costs for any given yield. It is also possible to calculate the yield and price necessary to cover costs and to produce any given margin of profit.

Whetham, E. H. & Currie, J. I.

A Record of Agricultural Policy, 1956–58.

Fm Econ. Br. Occ. Pap. No. 5, 1958. 4s. Post Free.

This continues for a further two years the record of British agricultural policy contained in the earlier papers in this series. Part I contains an analysis of recent changes in the aggregate agricultural income compared with the national income, and in the net income accruing to farms of varying types and sizes.

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CAMM, B. **Take Your Budget to the Bank.** *Poult. Fmr.* 1959, **141** (3645), 16.

1522* JAMES, B. J. F. **Some Aspects of Broiler Production.** *Westminster Bank Rev.* Aug., 1959, 13–16.

JAMES, B. J. F. **The Broiler Industry and its Economic Background.** *Quart. J. N.A.A.S. Poult. Sect.* 1959 No. 52a, 1–10.

NIX, J. S. **Economics of Farm Mechanisation.** *Westminster Bank Rev.* Nov. 1958, 10–11.

NIX, J. S. **What it Costs to Dry and Store.** *Fmr & Stk-Breed.* 1958, **72** (3603), Suppl. 12–13.
1504* NIX, J. S. **The £ s. d. of Sugar Beet Harvesting.** *Pract. Pwr Fmg.* 1958, **21** (6), 27, 29.
1504* NIX, J. S. **By Hand or Machine?** *Pract. Pwr Fmg.* 1959, **22** (3), 33.
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1488* STURROCK, F. G. **Designing Cattle Yards to Save Labour.** *Esso Fmr.* 1958, **10** (2), 14.
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WALLACE, D. B. **What's in it for Me?** *Fmrs Wkly.* 1959, **50** (3), g.
WALLACE, D. B. **Simple Accounts.** *Fmr & Stk-Breed.* 1958, **72** (3597), 61; **72** (3600), 93; **72** (3601), 73.

AGRICULTURE

ENGLEDOW, SIR F. L.

Agricultural Progress.

Foundation Oration. Kumasi College of Technology, 2 March, 1959. Pp. 7.

Cocoa brought from a distant land has been an important foundation for agricultural progress in Ghana. Such fortunate sudden advancement cannot be expected to happen twice.

In Ghana many of the types of agriculture associated with tropical soil and climate are widely practised. All these systems, especially shifting cultivation, have served their day but cannot serve the future. The country must aim at more continuous use of land, less reliance on a single crop, greater output of food and also of cash crops. The problem central to all this is maintenance of soil fertility, with the land more continuously in use.

Supply of capital, marketing improvements and thoroughgoing change in land tenure are recognised problems. Scientific and technical advancement depends on the scientists getting more basic knowledge and the cultivators applying it. Part of this basic knowledge concerns husbandry methods, and part specialisms such as soil characteristics and pathology.

A strong, highly trained Advisory Service is essential and to supply this must be one of the College's high aims.

ENGLEDOW, SIR F. L.

Report on Federal Organisation for Agricultural, Veterinary, Forestry and Fisheries Research. Pp. 14.

Federation of Nigeria Sess. Pap. No. 4, Lagos, 1959. Price 9d.

The services required for Agriculture (and Veterinary, Forestry and Fishery matters also) for purposes of improvement and development are classified according to function. Proposals are then made for allocating the various classes of service to either federal or territorial control. Research on problems of agricultural science inherent in the agriculture of all Regions of the Federation and basic in character are recommended for centralisation under the Federal Government, organisations of Institute type rather than Government Departments being set up for the purpose. Other services, of which Advisory or Extension Work is the chief, should be under territorial governments. To ensure the flow of new knowledge on which advisory work depends, Regions would look to the Federation in branches of agricultural science, but on husbandry matters would need their own Husbandry Experiment Stations. Proposals for the required arrangements are made.

ENGLEDOW, SIR F. L. (Chairman).

Technical Problems of Welsh Agriculture.

Report of a Committee appointed by the Agricultural Improvement Council for England and Wales. Pp. 19. H.M.S.O., 1958. Price 1s.

All the major technical problems of Welsh agriculture are also found in various parts of England and Scotland, but some of them occur in the Principality with such severity as to require fresh examination. Examples are: drainage, fertiliser requirements, nutritive value of pasture in high rainfall areas, losses through liver fluke in both cattle and sheep, and also a group of disorders including hypomagnesaemia, for which farming opinion more and more blames pasture improvement by fertilisers and reseeding with new strains. On many familiar matters, e.g. manurial requirements of crops, best available knowledge is from experiments under decidedly different soil and climatic conditions.

1480* HUTCHINSON, SIR J. B.

The Objectives of Research in Tropical Agriculture.

Emp. Cott. Gr. Rev. 1958, **35**, 231–38.

A discussion of the balance between long-term and short-term research proper to the present state of development of African agriculture.

1505* Hutchinson, Sir J. B. *and others.*

The Planning of a Large Farm for the Namulonge Cotton Research Station in Uganda.

Emp. Cott. Gr. Rev. 1959, **36,** 81–134.

The development of a specialist research station involves something more than the provision of research facilities for a group of scientific disciplines, and the policy of the Empire Cotton Growing Corporation in encouraging a broad approach to cotton problems in relation to agricultural development as a whole made it possible to study at Namulonge some of the problems involved in the establishment of a modern highly productive farming system in a rain-fed equatorial region.

Arable farming on this scale is not practised in Uganda, and some justification may be thought necessary for setting up so large an experimental farm. Its basic justification is the need to produce a large enough initial pedigree seed increase to make further multiplication possible in areas divided into small peasant holdings. It has, however, the additional very great advantage that it has made possible a study of intensive farming over the whole of a natural land unit, the ridge of land (*mutala*) between two swamps. Only on the data available from such a study will it be possible to plan intensive farming on small peasant farms without doing violence to the fundamental needs of conservation of the land. Moreover, it is by farming, and not merely by the conduct of experiments, that the agricultural potentialities of an area are revealed.

The experience of 8 years' practical farming is here presented. The data obtained are not such as could have been produced from formal experiments. They are not of high precision and the conclusions reached are of necessity provisional, and subject to revision in the light of further experience. Nevertheless, a farming system has been worked out that bears promise of high and sustained yields of the kind of produce that the country needs, and as a starting point for more advanced studies it seems proper to put it on record.

Namulonge farming experience falls naturally under three heads: the planning of the cropping system, the conditioning and storage of farm produce, and the evaluation of the local race of cattle and its place on the farm. Each of these heads is discussed in a chapter written by those who were directly concerned with that side of the work.

Mansfield, W. S.

The University Farm.

Golden Sheaf. 1959, **10** (2), 33–35.

ANIMAL BREEDING AND GENETICS

1515* Gilmour, D. G.

Segregation of Genes Determining Red Cell Antigens at High Levels of Inbreeding in Chickens.

Genetics. 1959, **44,** 14–33.

Immune sera made in individuals of the highly inbred RE line of White Leghorn chickens, and in both sets of backcross progeny from a cross of another line (WA) with RE, were used to identify a series of antigens of the red blood cells of chickens. Genetic evidence from inbred and backcross matings showed that the genes determining these antigens occurred at five independent, i.e. not apparently linked, loci segregating in the RE line. In three cases partial dominance was shown by the presence of a dosage effect.

Tests with reagents sent from America showed that three of these loci corresponded with the *A*, *B* and *C* loci already reported by American workers, while the other two (*L*, *N*) were new. A further antigen which had been identified but whose mode of inheritance had not been clearly worked out was shown by such tests to be determined by an allele at the *E* locus of American workers. The probable close linkage of *A* and *E* was confirmed.

A detailed study of the *B* locus showed the presence of nine multiple alleles each determining a separate antigen, distinguished by differing cross-reaction, absorption, and immunisation characteristics, among four highly inbred lines of widely different origins.

Two further loci were segregating in the RE line. One of these was *D*, identified only by American reagents, the other a locus determining the agglutinability of chicken red cells by vaccinia virus. In the latter case non-agglutinability appeared to be determined by a single gene recessive to the agglutinability gene.

Thus seven independent loci were segregating in the 1953 hatch of the RE line produced by the fourteenth successive annual brother-sister matings. Attempts were made to identify further antigen loci, which might have become fixed differently in different lines by random drift, by making immunisations between both backcross progeny and individuals of different lines, but without success.

1498* Harrington, G.

Boar Progeny Testing Reports—First Comparison.

Pig Breed. Gaz. 1959, **96,** 74–77.

A method is described whereby the average results for boars tested at the National Pig Progeny Testing Board's stations may be quickly compared. This involves attaching a rating to each boar for a particular characteristic according to the quartile of the distribution in which the boar's average lies. Reasons are given why six characteristics should be considered of first importance in the appraisal of progeny testing results. The boar ratings for these six (food conversion, average back-fat, length, eye muscle score, shoulder score and ham

score) provide a very convenient numerical method of expressing the relative merit of a boar according to the progeny test. Some interesting facts emerging from the few reports available at the time of writing are discussed.

1497* Joubert, D. M. & Hammond, J.

A Cross-breeding Experiment with Cattle, with Special Reference to the Maternal Effect in South Devon-Dexter Crosses.

J. Agric. Sci. 1958, **51,** 325–41.

An investigation was carried out to determine the extent of the maternal influence on size of calves at birth and during subsequent stages of growth, by making reciprocal matings between large South Devon and small Dexter cattle. As a preliminary to the experimental results, data concerning the respective parent breeds were analysed. From the first part of the study the following information was obtained:

The mean weight at birth of purebred South Devon calves was $100{\cdot}3 \pm 1{\cdot}47$ lb. with a tendency, though not statistically significant, for male calves to be heavier. Calves born during the months April to July appeared to be heavier than those born at other times, but the age of the dam had no definite effect on the birth weight of offspring. It was found, however, that the sire may influence birth weight to a significant degree.

The mean period of pregnancy for South Devon females, carrying purebred foetuses, was $287{\cdot}0 \pm 0{\cdot}42$ days the tendency being for males to be carried longer, but the difference of 0·97 days was not statistically significant. A statistically significant difference indicated that winter calvers carry their foetuses longer as a rule, but though heifers have shorter gestation periods than cows, the difference of 1·6 days was not significant.

The mean birth weight for purebred Dexter calves was 52·3 lb., males averaging 1·9 lb. more than females, but this difference was found not to be statistically significant. Birth weights were lowest at the end of winter, while a tendency existed for the weights to increase from the first to the third pregnancy of cows. It was shown that long-limbed Dexter calves tend to be heavier at birth than calves classified as short-limbed. Data on twins indicated that the pair weighed 44·2 per cent. more than single calves, while individual twins weighed 38·8 per cent. less than singletons.

The mean duration for purebred Dexter pregnancies was 287·2 days, males being carried only 0·4 days longer than females. A strong positive correlation ($r = 0{\cdot}713$, $P < 0{\cdot}01$) was found between birth weight and duration of pregnancy. Though a correlation was established between birth weight and placental weight, due to the limited number of observations this was not of statistical significance.

From the second part of the study which deals with the experimental reciprocal crosses, the following results were obtained:

The difference in weight between the South Devon sire and Dexter females amounted to 1486 lb. (152 per cent.), while that between the Dexter sire and South Devon females amounted to 496 lb. (93 per cent.). Body measurements of the respective groups of females indicated important conformational differences between the two breeds.

The South Devon dams carrying crossbred foetuses had a pregnancy period of 290·3 days, compared with 278·0 days for the Dexter dams. The calves out of the former averaged 73·4 lb. at birth, while those out of the latter weighed 59·1 lb. on an average, a 14·3 lb. (24·2 per cent.) difference. The weight of the placenta was 10·6 lb. in the large dams and 3·2 lb. in the small ones. Only in a single instance was a small (Dexter) dam unable to give birth to her crossbred foetus.

Data on the growth of the calves up to 12 months show that the difference between the reciprocals increases up to approximately the seventh post-natal month, following which stage it gradually diminishes. It was not possible to determine the effect of the maternal environment at ages approaching maturity. The growth of the crossbred calves were compared also with those of purebred South Devons and Dexters.

OTHER PAPERS

GILMOUR, D. G. **Blood Groups in Poultry.** *Quart. J. N.A.A.S. Poult. Sect.* 1959, No. 52a, 1–10.
HAMMOND, J. **Breeders must Test their Boars.** *Pig Fmg.* 1958, 6 (11), 23.
HAMMOND, J. **Pig Recording.** *PIDA Bull.* 1959 (June), 2–4.
HAMMOND, J. **Stock Breeding and Performance.** *Field.* June 18, 1959.

ANIMAL NUTRITION

1519* Brookes, A. J. & Hodges, J.

Studies in Beef Production. I. Effects of Level of Feeding and of Breed on the Growth and Fattening of Spring Born Cattle.

J. Agric. Sci. 1959, **53,** 78–101.

The sources of calves for rearing for beef are discussed and the dependence of the beef industry upon the dairy industry demonstrated.

An experiment designed to compare the effects of four levels of feeding on the growth rate, conformation, economy of food conversion and type of carcase produced, of three breeds of spring-born steers, Hereford,

Dairy Shorthorn and Friesian, is described. The levels of feeding are high or moderate in the calf stage, each followed by high or moderate feeding in subsequent winters.

The results on growth and time of fattening are given and discussed.

The calves fed on a high level were almost twice the weight of those fed on a moderate level at 8 months old.

The well-reared calf had an advantage over the moderately reared calf for the rest of its life.

Although calves which had been reared moderately showed a marked improvement in growth rate when subsequently fed on a higher level they did not reach the weight of calves fed well throughout at 2 years old.

The level of feeding in the calf stage had little effect upon the time of fattening provided that the level of feeding in the winter periods of subsequent life was on a high level.

When subsequent feeding was on a moderate level in the winter months, the calf reared well initially fattened on grass a year earlier than the moderately reared animal.

The high-moderate treatment is shown to be the most satisfactory from many points of view. On this treatment a minimum of concentrates is used in the production of beef.

The moderate-moderate cattle may be too heavy for present-day requirements when finished off grass at $3\frac{1}{2}$ years old.

Cattle which were fed on a high level in winter from 8-14 months put on less live weight in the following summer than those fed moderately. A live-weight gain of about 1 lb. a day in winter would appear to be satisfactory if the cattle are to make good use of grass in the following summer.

These main feeding treatment effects applied to the three breeds used.

The Friesians were heavier than Dairy Shorthorns or Herefords as calves, and the live weight at most ages was in descending order Friesians, Dairy Shorthorns, Herefords.

The growth rate of Friesian steers was higher than that of the other two breeds at most stages of life, but the difference between Dairy Shorthorns and Herefords was negligible.

The Herefords finished earlier than the Dairy Shorthorns and Friesians when fattened in yards or on grass.

There was some indication (Brookes, 1954, Publ. Brit. Vet. Ass. No. 24) that husk and ringworm caused less trouble with cattle which had been well reared than with those moderately reared.

1486* Lea, C. H., Parr, L. J. & Carpenter, K. J.

Chemical and Nutritional Changes in Stored Herring Meal.

Brit. J. Nutr. 1958, **12,** 297–312.

Herring meal, prepared by hot-air drying of the press-cake, was stored at two moisture contents (11·1 and 6·2 per cent.) and three temperatures (37, 25 and 100°) in air and in nitrogen.

Chemical examination showed a very rapid oxidation of the oil of the meals stored in air, particularly during the first few weeks. Oxidation was more extensive at the lower moisture content and at the lower storage temperatures, leading to darkening of the meals and to darkening, reduction in iodine value and solidification (polymerisation) of the oils extracted from them. These changes did not occur in whole meals stored in nitrogen or in defatted meals stored in air.

Despite extensive oxidation of the oil of the air-stored samples the amount of lipid extractable by solvents decreased by not more than 4 per cent. of the initial value during 4 months' storage. After 12 months the low-moisture meal had lost 6–8 per cent. and the high-moisture meal 11–15 per cent. of its extractable lipid, corresponding approximately to 1 and 2 per cent. of the meal.

The "available lysine" in the meal was reduced by only 4 per cent. during $2\frac{1}{2}$ months' storage in air at 25°, and feeding tests with chicks failed to indicate any more serious reduction in the value of the meal as a source of supplementary protein. After 12 months the decrease in available lysine was 9 per cent., but no decrease occurred in whole meals stored in nitrogen or in defatted meals stored in air.

The anti-oxidant 2, 6-di-*tert.*-butyl-4-methylphenol (BHT) added to the meal at a concentration of 0·005 per cent. (together with 0·005 per cent. citric acid) considerably retarded oxidation of the oil.

The advantages and possible disadvantages of stabilising the oil of fish meal against oxidation are discussed.

Leat, W. M. F., *et al.*†

Die Struktur des Ubichinons aus Schweineherzen.

Helv. Chim. Acta. 1959, **41,** 2343–57.

The isolation in pure form of the ubiquinone from pig heart is described. From 750 kg. raw material 37 g. of pure crystalline material could be obtained. Its structure has been established as that of a 2,3-dimethoxy-5 methylbenzoquinone derivative with a vitamin-K_1- like isoprenoid side chain of 50 carbon atoms. It is proposed to name this compound ubiquinone (50).

† Work carried out from the Dept. of Biochemistry, University of Liverpool.

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1481* CARPENTER, K. J. **Changes in Stored Herring Meal. I. Nutritive Value of the Protein.** *Proc. Nutr. Soc.* 1958, **17,** xxviii.

1527* CARPENTER, K. J. **Energy Value of Poultry Foods.** *Agric. Merch.* 1959, 39 (8), 47-50, 60.

1502* Bodwell, C. E., Everitt, G. C., Harrington, G. & Pomeroy, R. W.

An Investigation of the Repeatability of Eight Measurements of Beef Carcasses.

Anim. Prod. 1959, **1,** 51–59.

Three measurements on both sides of 15 carcasses and 5 additional measurements on both sides of 6 carcasses were taken in duplicate by 3 observers working independently. The carcasses, which ranged in weight from 520–884 lb., were measured from 2–6 hr. after slaughter while on the hook in the chill-room of a slaughter-house.

Length of body and loin were the measurements which could be taken the most consistently, whereas the 2 depth measurements and the length of tibia were the least repeatable.

For 2 measurements, there were marked differences between observers in the average differences between sides. In all carcass investigations, measurements should be taken on both sides and averaged.

For all measurements, except the length of body and loin, there were differences in the average values found by the 3 observers.

It is suggested that to achieve a satisfactory degree of repeatability, slight redefinition and clarification of the points of reference is required for some measurements, whereas others may have to be discarded.

1499* Brush, M. G.

Adrenocortical Activity in Bovine Pregnancy and Parturition.

J. Endocrin. 1958, **17,** 381–86.

The plasma 17:21-dihydroxy-20-keto-corticosteroid levels in the cow in late pregnancy (33–0 days before calving) are only slightly higher than in the cow soon after calving (0–99 days). A larger rise was sometimes seen in the last few days before calving.

Except in one case where calving was difficult, no evidence of increased levels associated with the time of labour was found.

Higher levels in the first day or two after calving were seen in some cases, but subsequently levels were uniformly low—the difference from earlier levels being statistically significant ($P = 0{\cdot}01$).

In general, these results are in contrast with the human picture. Possible reasons for these findings are discussed.

1500* Cock, A. G.† & Cohen, J.

The Melanoblast Reservoir Available to a Feather Papilla.

J. Embryol. Exp. Morph. 1958, **6,** 530–45.

In an adult black-red hen which, when a newly hatched chick, had received a homograft of skin from the back of a dominant white chick, active feather papillae have been exchanged between follicles of the neck and the homograft. The distinctive structure of feathers of the two tracts permits reliable identification of feathers growing from these transplanted papillae.

Each of six successful transplants from the neck into the homograft has so far produced only black-red feathers (one to three feathers in each case). Five transplants from the homograft into the neck have so far produced from two to five feathers each, with the following sequences of pigmentation types: white—white—white—white—mosaic; black-red—black-red—mosaic—mosaic—mosaic; black-red—white—white—white—black-red; white—white—black-red; white—white. A follicle on the homograft, about 1 cm. in from the edge, and not subjected to any operative interference, has produced three mosaic feathers in succession, each partly pigmented by host-type (black-red) melanocytes.

It is concluded (*a*) that the papilla of a feather follicle contains a reservoir of melanoblasts sufficient to provide the melanocytes of several future feathers; (*b*) that this reservoir is from time to time augmented by melanoblasts migrating in from the surrounding tissue; and (*c*) that some of the melanoblasts within a papilla may remain inactive during the growth of one or more feathers, but contribute melanocytes to subsequent feathers.

In the vane of each of the seven feathers which are mosaic in respect of their melanocytes, there is a marginal band of intense black where the black-red area adjoins the white. This, it is suggested, may be due to the diffusion of some substance from the white area, and may depend on the fact that the dominant white melanocytes also carried the gene for extended black.

Our findings are discussed in relation to previous work on the pigmentation of feathers and hairs.

† Present address : Agricultural Research Council Poultry Research Centre, West Mains Road, Edinburgh, 9.

1493* Everitt, G. C.

Some Preferences of Butchers for Beef Cattle.

Inst. Meat Bull. 1958, **22,** 33–41.

In summarising the above discussion it is apparent that the most important factor influencing the pattern of buying was live weight and this factor operated more in heifers than in steers. Variations in the prices paid due to quality, as exemplified by grade, were less than the variations due to live weight but the price differentials between grades were greater than the differentials between steers and heifers. At the same live weight price differentials between grades were generally greater in steers than in heifers. Breeds and crosses received the least degree of discrimination in preferential buying but this was more apparent in steers than in heifers.

The general pattern of prices paid for different weights and qualities of beef cattle shows that butchers buying at auction markets exhibit certain preferences and these preferences are explicable, partially at least, on a basis of growth and development.

1494* Gatherum, D. P., Harrington, G. & Pomeroy, R. W.

A Study of Certain Subjective Assessments Important in Animal Improvement.

Occup. Psychol. 1958, **32,** 229–35.

An experiment is described in which two judges assessed 35 bacon sides, presented in 7 batches of 20 at a time so that each appeared four times during the trial, for the "proportion of lean to fat". During the following months the same judges repeated the experiment three times using slightly different procedures, making their assessments from half-size or full-size black and white photographs of the same sides presented in the same arrangements.

The mean scores awarded on examination of the bacon and of the photographs were closely correlated. The main differences between procedures which the comparative trial showed concerned the degree of discrimination attempted and the consistency of assessment achieved for the judgements on the bacon compared with those on the photographs. When judgements were made on the actual bacon the judges used a narrower span of scores than they did with the photographs. One judge was able to make his assessments more consistently when using the narrower range and his effectiveness of discrimination was at a similar level to that achieved when judging the photographs, whereas the other, being definitely more erratic in his assessments on the bacon than on the photographs, was able to discriminate between bacon sides less effectively.

The investigation suggested that judging trials carried out with photographs and with the actual product may yield divergent results, although it could not indicate which procedure measured most accurately the variations occurring under practical judging conditions.

1516* Gatherum, D. P., Harrington, G. & Pomeroy, R. W.

Visual Judgements of Quality in Meat. I. Assessments of the Proportion of Lean to Fat in Bacon from Photographs of the Cut Side.

J. Agric. Sci. 1959, **52,** 320–31.

Eight experienced judges used a 20-point scoring scale in different ways when assessing the "proportion of lean to fat" from the same photographs of cut bacon sides presented in the same arrangements. The average score for the 220 judgements made during the experiment by a single judge, which represents his over-all level of scoring or "standard of judging", ranged from 13·7–12·0. The standard deviation, a measure of the degree of discrimination attempted by the judge, ranged from 3·26–4·74.

The judges varied in their consistency of assessment or "repeatability". The standard error for a single judge, measuring the extent of the variation of his scores within photographs, ranged from 0·89–1·99. The judges who attempted to discriminate most between photographs tended to be the least consistent in their judgements, although one judge was a notable exception to this trend.

The consistency of judgement tended to decrease from the good (high-scoring) rashers to the poor (low-scoring) rashers, but this effect was more marked for some judges than for others.

Some of the variation in the scores awarded to each photograph was due to alterations in the standard of judging from batch to batch. When this was allowed for, the standard errors were all reduced and ranged from 0·61 -1·31. The judges tended to adjust their standards according to the average quality of the batch being assessed. This led to the variation among the average scores for the batches being less than it would have been had their standards remained constant.

Alterations in the standard of judging during the experiment affected the scores awarded to good (high-scoring) rashers rather less than those awarded to poor (low-scoring) ones.

The correlations between the individual judge's mean scores for the forty-four photographs and the over-all mean scores were very high. For seven judges, they ranged from 0·962 -0·984, whereas for the eighth judge the correlation was 0·918. The lower correlation for this judge was due to two rashers with very thin fat being heavily marked down.

The correlations between the over-all mean scores and two different combinations of three objective measurements were both about 0·92; these measurements were therefore slightly less closely related to the over-all scores than were an individual judge's mean scores.

The possibility of making the experimental technique more realistic and of improving the precision of such visual judgements by providing photographic scales of reference are discussed.

Hammond, J.

Fertility in Cattle. An address.

Santa Gertrudis Breeders International, San Antonio, Texas, 1959. Pp. 37.

Hammond, J.

Growth and Meat Production.

Contr. to *Handbuch der Tierzüchtung.* 1958, **1,** 197–247.

Ed. by J. Hammond, I. Johansson and F. Haring in 3 volumes.

Paul Parey, Hamburg. DM. 88 per vol.

1508* Hammond, J.

Pregnancy.

K. VetHöjsk Aarsskr. 1959, 1–6.

There are three distinct stages during pregnancy, each of which is marked by a different form of nutrition. In the *blastocyst stage* nutrition is derived from the uterine secretions; it is postulated that the level of a special substance in these determines the number of blastocysts which will survive and so the proportion of foetal atrophy. In the *embryonic stage* nutrition is derived from the activity of the trophoblastic cells; these give the embryo a priority of nutrition from the blood stream over most other maternal tissues. At this stage the area over which the placenta extends determines, through nutrition in the subsequent stage, the size of the young at birth. In the *foetal stage* the activity of the trophoblastic cells ceases and nutrition is derived from transfusion of nutrients between maternal and foetal blood streams; consequently the level of nutrition of the dam is of great importance. The rapid increase in size of the foetus itself at this stage is caused by increase in the size of the muscle cells; the number of muscle cells and so the ultimate maximum size of the adult has already been determined by the end of the preceding stage.

These principles are illustrated by references to experiments on farm animals.

Hammond, J.

Principles of Growth. Pp. 15–16.

Contr. to *Beef Production Bull. No.* 178, *Minist. Agric. Lond.*, 1959. Price 5s.

1506* Hammond, J.

Twinning in Cattle for Beef Production.

Vet. Rec. 1959, **71,** 168–69.

Gives scientific details necessary for twinning, both in artificially inseminated dairy herds and pure beef breeds.

1518* Harrington, G. & Pomeroy, R. W.

Yields of Wholesale Cuts from Carcasses of Aberdeen-Angus Crosses Fattened on Grass and in Yards.

J. Agric. Sci. 1959, **53,** 64–77.

Both sides of 68 carcasses of Aberdeen-Angus cross steers and heifers were broken down into wholesale joints by the same butcher using a modification of the London and Home Counties style of cutting. Thirty-four of the cattle were fattened on grass in the summer of 1955 and the other 34 in yards during the following winter.

Sides of steer carcasses averaged some 50–60 lb. heavier than those of heifers both in summer and winter, and the yard-fattened cattle gave sides averaging 10–20 lb. heavier than those from grass-fattened cattle.

The cuts along the underline of the animals (brisket and flanks) were increasing in weight at proportionally the greatest rate and the shin and hind-leg cuts at about half this rate, with those along the top of the back intermediate.

At a side weight of 300 lb., steers were significantly lighter than heifers in the weight of kidney knob, cod fat, thin flank, forequarter flank, loin and rump, whereas they were significantly heavier than heifers in weight of leg, shin, topside, top rump and the neck cuts (clod and sticking). These differences suggested that at this weight of side, heifers were at a more advanced stage of development than steers.

Animals fattened in yards yielded, at a side weight of 300 lb., a greater weight of rump, top rump, silverside and the neck cuts than did animals fattened on grass. The latter showed greater development of brisket, thin flank and skirt at this weight. A slight alteration in cutting technique during the test could have affected this treatment comparison.

Coefficients of variation measuring, among animals of the same type and carcass weight, variability of the mean weight of the two examples of a particular cut from each carcass ranged from 2·1–12·2 per cent. for the main joints. The kidney knob, cod fat and skirt showed greater variation, the coefficients being 25·5, 15·9 and 13·9 per cent., respectively.

Open (left) sides averaged 2·7 lb. heavier than close (right) sides and gave a significantly greater weight of loin, middlerib and, in heifers, kidney knob. Close sides gave a significantly greater weight of the neck cuts and silverside.

Measures of cutting variations showed that the kidney knob, cod fat, skirt and flank cuts were the most difficult to remove in a standard manner.

The index of wholesale carcass value (calculated from the cutting yields and average wholesale prices) ranged from 17·806 pence/lb. to 19·568 pence/lb. among the 136 sides and tended to decrease as weight of side increased.

The sexes did not differ significantly at a side weight of 300 lb. in the index of wholesale value, whereas yard-fattened animals at this weight gave sides worth 0·17 pence/lb. more than those fattened on grass.

The index of wholesale carcass value varied more among animals fattened on grass than among those fattened in yards.

The index of wholesale carcass value was highly correlated with the percentage yield of the combined loin, rump, top rump and round from both sides, the standard error of prediction being 0·098 pence/lb. compared with the overall standard deviation for the index of 0·258 pence/lb. There was a considerable decrease in the accuracy with which the index could be predicted if this yield was measured from one side only, or if the leg cut was not removed.

The need for standardisation of cutting methods, the use of indices of carcass value in experimental work, and the introduction of certain experimental cuts as an aid to the measurement of carcass conformation, are discussed.

MANSOUR, A. M.

Hormonal Control of Ovulation in the Immature Lamb.

J. Agric. Sci. 1959, **52,** 87–93.

Thirty-four lambs varying from 1 week old up to 22 weeks have been treated with: (*a*) P.M.S. alone; (*b*) Progesterone + P.M.S.; (*c*) P.M.S. + chorionic gonadotrophin (C.G.).

At 1 week old the lamb's ovaries were unresponsive to treatment (*a*).

At 4 weeks follicular growth was obtained in groups treated with both (*a*) and (*b*).

At 8 weeks of age follicular stimulation was obtained from treatment (*a*), follicle luteinisation from (*b*), and ovulation from (*c*).

At 10 weeks luteinisation was observed in (*b*) and ovulation in (*c*).

At 12 weeks luteinisation occurred following treatment (*a*) and ovulation followed treatments (*b*) and (*c*).

At 16 weeks ovulation was obtained from treatment (*a*).

The absence of ovulation in the groups treated with P.M.S. (alone) and progesterone + P.M.S. indicates the absence of the factor concerned with ovulation (L.H.) in the immature lamb's pituitary, until 16 weeks old. The occurrence of luteinisation at 8–12 weeks of age in these groups indicates that this factor (L.H.) begins to appear at low level at that time.

OTHER PAPERS

1496* HAMMOND, J. **Beef from the Dairy Herd.** *Agriculture, Lond.* 1958, **65,** 427–29.
1489* HAMMOND, J. **Bulls for Dairy-bred Beef.** *Fmr & Stk-Breed.* 1958, 73 (3606), 72–73.
1507* HAMMOND, J. **Induced Twinning in Cattle Could Increase Supplies.** *Irish Independent,* April, 1959.
1483* HAMMOND, J. **Observations on Meat Production in New Zealand and Australia.** *Bull. Inst. Meat.* 1958 (23), 17–24.
1509* POMEROY, R. W. **Beef Production.** *J. R. Agric. Soc.* 1958, **119,** 35–40.
POMEROY, R. W. **Quality Requirements of British Beef Market.** Paper read to the Agric. Sci. Assoc., Dublin, Sept., 1958. (Cyclostyled).
POMEROY, R. W. **Public Taste in Meat: Producers Problem to Please both Butcher and Consumer.** *Times Suppl.* 8 Dec., 1958, p. 8.
POMEROY, R. W. **Recent Developments in Assessing Carcass Quality.** *N.A.A.S. Quart. Rev.* 1959, No. 44, 172–76.
POMEROY, R. W. **Role of the Aberdeen-Angus in Beef Production.** *Aberdeen Angus Rev.* 1959 (29), 40–41, 47.

BIOMETRICS

1492* BRAUDE, R., TOWNSEND, M. J., HARRINGTON, G. & ROWELL, J. G.

A Large-scale Test of the Effects of Food Restriction on the Performance of Fattening Pigs.

J. Agric. Sci. 1958, **51,** 208–17.

A co-ordinated trial has been carried out at twenty-six centres to study the effects of feeding different quantities to food to fattening pigs. The treatments studied were *ad lib.* feeding throughout, *ad lib.* feeding to 120 lb. live weight after which the amount of food given was restricted to 6·5 lb./pig/day and two scales of feeding according to live weight, one moderate and one severe.

Food conversion was best for the pigs on the most restricted feeding scale, being 8 per cent. better than that for the pigs fed *ad lib.*

The slower growing pigs were less fat, slightly longer and their depths of eye muscle were greater.

The *ad lib.* fed pigs had higher killing-out percentages and higher weights into cure.

The bacon sides from pigs fed on restricted diets yielded a higher proportion of gammon and fore-end and had thicker streaks.

Restriction of feeds led to softer fats.

An economic appraisal has been made which shows that, on the basis of certain assumptions, the medium feeding scale would have led to a smaller profit per year than the *ad lib.* or the *ad lib.* restricted treatments *under the price structure and system of grading prevailing during the period of the experiment.*

Changes in the price structure (average price of bacon pigs, differentials between grades and cost of meal) have a substantial effect on the relative profits obtained by feeding different amounts of food.

Small changes in food conversion (of the order of a difference of 0·1 between *ad lib.* and moderately restricted feeding) also have a substantial effect on relative profits (the same effect as a change of 4s. per score in the price of grade A pigs).

1495* CAMPBELL, R. C. & PATERSON, H.

Effect of Supplementary Heating on the Rearing of Pigs.

J. Agric. Sci. 1958, **51,** 234–36.

An experiment was carried out at ten farms in four winters to compare the value of three methods of pen warming.

Complete information on weight gain was available in seventeen replicates; the average increase in weaning weight from the use of heat was 2·41 lb.

Information on survival was available for thirteen replicates; the average benefit from the use of heat was 0·58 pigs weaned per litter.

The farmers' comments showed that they considered heating to be of value.

1510* Chubb, L. G. & Rowell, J. G.

Counting Blood Cells of Chickens.

J. Agric. Sci. 1959, **52,** 263–72.

Six methods of diluting chicken's blood prior to counting erythrocytes and leucocytes in haemacytometers have been studied. No difficulty is found in recognising erythrocytes. The most satisfactory method of counting leucocytes was the method described by Natt & Herrick (*Poult. Sci.* **31,** 735, 1952) in which the diluent contains methyl violet. Formulae are given which enable standard errors of estimates to be calculated.

Three methods of staining blood smears for the differentiation of the various leucocytes have been studied. The method using Leishman's stain appeared to result in good differentiation and was simple to use. However, an experiment to study sampling errors has shown that there may be considerable differences between observers in the percentages of lymphocytes and heterophils when the latter are high, showing that the estimates of these quantities may be biassed. These differences may have been caused by a tendency for heterophils to concentrate to the edges of the smears and for the observers to select different fields for their counts.

Although blood counts varied only slightly during the day, there were considerable differences from day to day. The average erythrocyte count for ten chickens fluctuated between about 2·9 and 3·5 millions per $mm.^3$ during the first 3 weeks after hatching and was more steady for the next 4 weeks at about 2·9 millions per $mm.^3$ The average leucocyte count rose from about 10,000–35,000 per $mm.^3$ during the first 7 weeks of life, the rate of increase being greatest when the chickens were youngest; the rise was mainly due to a rise in the number of lymphocytes.

There were also considerable differences in blood counts between chickens even though environmental and genetic conditions were standardised as far as possible.

1485* Fenton, B. K., Elliot, J. & Campbell, R. C.

Effects of Different Castration Methods on the Growth and Well-being of Calves.

Vet. Rec. 1958, **70,** 101–3

Seventy-six calves were allocated to three groups for castration by three different methods: "Burdizzo", "Elastrator", and "Open". Eight calves were left uncastrated as controls.

The physical changes and weight gains of the calves in each group were recorded weekly for 6 weeks. Statistical analysis showed significant differences in growth rate between castrated and uncastrated animals.

A very significant difference in growth rate between the animals in the "Elastrator" group and the remaining groups is recorded in the week ending on the 28th day after castration. The difference coincided with the more prolonged period of pain and sepsis which is characteristic of this rubber-ring method.

CROP HUSBANDRY

1491* Hutchinson, Sir J. B., Manning, H. L. & Farbrother, H. G.†

Crop Water Requirements of Cotton.

J. Agric. Sci. 1958, **51,** 177–88.

Attention is drawn to the enormous variations in yield experienced in commercial cotton growing under rain-fed conditions. Yields at Namulonge have ranged from 161–1163 lb./acre.

In seeking an explanation of this enormous variation past and present fertiliser trials in Uganda have failed to show that much of this variation is due to nutrient status.

From Manning's previous analysis of yields in relation to seasonal rainfall, over many district trials, it is evident that 20–25 in. of rainfall per season is optimum.

The purpose of more recent studies has been to examine the effect of distribution of rainfall within the season. Clearly the pattern of crop water requirement, also within the season, must supersede a simple seasonal concept of crop water use.

Experimental evidence, based on several seasons' data, led to the conclusion that evapotranspiration rates exceeding the commonly accepted figure of 0·8*E* must in fact occur in order to provide a satisfactory explanation of results recorded.

The within-season pattern of water requirement of an annual arable crop is shown to be more dependent on its state of development than on the pattern of a physical model based on calculations of energy availability.

In agricultural science, responses of the order of 35 per cent. are considered noteworthy, whether it be in plant breeding, in fertiliser studies or in the control of pests and diseases. In the water relations study here reported, considering all yields of all crops of cotton grown on the main farm at Namulonge since 1950–51, variation of the order of 350 per cent. of the mean yield has been accounted for in terms of a model of crop water requirement based on leaf area.

† Work carried out at the Cotton Research Station, Namulonge, Uganda.

1501* Jarvis, R. H., Hanley, F. & Ridgman, W. J.

Effect of Leys on Soil Fertility. II. Effect of Undersowing with Grasses and Legumes on the Yield of a Barley Nurse Crop.

J. Agric. Sci. 1958, **51,** 229–33.

Data from a long-term experiment providing information on the effects on barley of undersowing the crop with various common species of grasses and legumes are discussed.

There is no evidence that the yield of grain, yield of straw, 1000 grain weight or the nitrogen content of the grain was affected in any way by undersowing with any of these species.

CROP PESTS AND DISEASES

1524* Dickinson, S.

Behaviour of Larvae of *Heterodera schachtii* on Nitrocellulose Membranes.

Nematologica. 1959, **4,** 60–66.

Larvae of *Heterodera schachtii* have been observed to adhere to and to force their stylets through nitrocellulose membranes containing wax. Adhesion on wax-free membranes seldom lasted for more than a few seconds. It is suggested that adhesion and the attempt to penetrate a root surface is a reaction to a purely physical stimulus, and that as a consequence specifity for particular host roots only occurs after stylet penetration has been achieved.

1523* Doling, D. A. & Hepple, S.†

Occurrence of Take-All in Cocksfoot and other Grasses.

Plant Path. 1959, **8,** 73–75.

In 1957 patches of dead plants due to take-all were found in several cocksfoot seed crops in the Holland Division of Lincolnshire. A crop of timothy was also affected. Many whiteheads were found in a seed crop of meadow fescue in Warwickshire in 1958. Attention is drawn to the possible significance of seed crops of ley grasses in the carry-over of take-all to cereals.

1517* Hepple, S.†

"Karathane": the Value of its Differential Fungicidal Effect in Relation to Mildew and Yellow Rust of Wheat.

Nature, Lond. 1959, **183,** 622.

In the study of rust diseases of cereals, especially yellow rust (*Puccinia glumarum* (Schm.) Erikss. and Henn.) secondary infection by cereal mildew (*Erysiphe graminis* D.C.) has often caused difficulties. It was found that the regular use of Karathane smoke controlled the mildew whilst leaving the rust unaffected.

1521* Lewis, T.‡

Annual Cycle of *Limothrips cerealium* Haliday (Thysanoptera) and its Distribution in a Wheat Field.

Ent. Exp. & Appl. 1959, **2,** 187–203.

Terrestrial and aerial populations of *L. cerealium* were studied simultaneously; ovarian dissections were made to detect different generations. The annual life cycle can be arbitrarily divided into six stages based primarily on the amount of flight activity: the females feed mainly on winter cereals and grasses in spring, many moving to later sown cereals in June and July, where most eggs are laid in the leaf sheaths of the young leaves. First generation females leave cereals in August to feed on grasses before entering hibernation.

Wheat ears with a water content of less than approx. 45 per cent. were not favoured by thrips. When winds blew consistently from the same quarter the initial infestation was greatest on the windward edge of the wheat crop.

1520* Lewis, T.‡

A Comparison of Water Traps, Cylindrical Sticky Traps and Suction Traps for Sampling Thysanopteran Populations at Different Levels.

Ent. Exp. & Appl. 1959, **2,** 204–15.

Thysanoptera drifting over and around a wheat field were trapped using black, green and white water traps, black cylindrical sticky traps and suction traps. Certain *Taeniothrips* spp., *Thrips* spp. and *Aeolothrips* spp. were strongly attracted to white but not to green or black; *Limothrips cerealium* Hal., *Chirothrips manicatus* Hal. and *Stenothrips gramium* Uzel were not markedly attracted to any of these colours. Above the crop catches in sticky traps were more consistent than those in water traps; at crop level, where suction traps were also used, their catches were more consistent than catches in either of the other types of trap. Up to 48 ft. the aerial density of all species decreased with height but the rapidity of the decrease differed between species.

† Work carried out at the National Institute of Agricultural Botany, Cambridge.

‡ Work carried out at the Imperial College of Science and Technology, London.

PATEL, R. M.†

Some Notes on the Biology of the Cabbage Gall Weevil.

Plant Path. 1958, **7,** 136–41.

Experiments on the formation of galls suggested that initiation did not take place during the egg stage of the weevil, but started as soon as the egg hatched into a first instar larva. Gall size progressively increased with the size of the larval instar. Aphid sticky traps failed to catch many weevils in flight but evidence was obtained that weevils are capable of flight in bright sunshine, especially in early summer. An experiment on feeding preferences suggested that turnips and charlock leaves were preferred to those of common cultivated brassicas. In a field survey of host plants among the cruciferous weeds and cultivated crops, a few new hosts were recorded, including *Coronopus squamatus* (Forsk) Ascher, on which galls are formed at the same time as on charlock.

† Present address: Crop Protection Officer, Ahmednagar, Bombay State, India.

PLANT BREEDING AND GENETICS

1487* HUTCHINSON, SIR J. B. & LEE, B. J. S.

A New Species of Gossypium from Central Tanganyika.

Kew Bull. 1958 (2), 221–23.

Description of *Gossypium longicalyx.*

1514* RICHENS, R. H.

Studies on Ulmus. II. Village Elms of Southern Cambridgeshire.

Forestry. 1958, **31,** 132–46.

In continuation of a preliminary study on the range of variation of East Anglian elms (*Watsonia*, iii (1955), a taxonomic survey was made of the village elms of southern Cambridgeshire. The number of samples collected was 132. For each of these, 8 quantitative and 1 qualitative character were measured. The samples could be classified into 7 biometrically defined groups, 6 pertaining to *U. carpinifolia* and 1 to *U. procera.* The two species are linked by intermediate forms.

At least two introductions of *U. carpinifolia* into Cambridgeshire seem to have occurred, one of which appears to have been no later than Roman. *U. procera* was introduced no later than in the Middle Ages.

SOIL SCIENCE

1511* CHILDS, E. C.

A Treatment of the Capillary Fringe in the Theory of Drainage.

J. Soil Sci. 1959, **10** 83–100.

The hodograph treatment of the problem of drain design, as developed by van Deemter, is suitably modified to take into account the presence of a capillary fringe above the water table. Examples are presented to show that the presence of the fringe requires an increase of optimum drain size, and that thick fringes are accommodated mostly above a water table which is not proportionately much depressed below that which is appropriate to an absence of fringe, while thin fringes are accommodated in approximately equal proportions above and below the level of the fringeless water table.

1513* CHILDS, E. C. & YOUNGS, E. G.

Use of Moisture Characteristic Curves in Assessing the Soil Stability of Opencast Coal Sites.

Proc. Int. Symposium on Soil Structure. Meded. LandbHoogesch. Gent. 1959, **24,** 415–20.

The stabilities of aggregation of soil samples of the worked and unworked soils from two opencast mining sites after restoration were determined by obtaining rough pore-size distribution curves from the moisture characteristics of 1–2 mm. crumb fractions of the soils after slow and quick wetting. The method which is simple and quick to carry out, indicates sensitively the breakdown of the soil crumbs during the quick wetting.

1484* YOUNGS, E. G.

Redistribution of Moisture in Porous Materials after Infiltration. 2.

Soil Sci. 1958, **86,** 202–7.

Moisture profiles during the redistribution after vertical infiltration to various depths into two inert porous materials were obtained using an apparatus employing thermo-electric elements to estimate moisture content. By an extension of the analysis used in Part 1 (Soil Sci. 1958, *86,* 117-25) for horizontal redistribution, the initial transition moisture content from the draining to the wetting zone was calculated from the hydrological

properties of the porous materials for various infiltration depths and compared with experimental values. This indicated that the redistribution of moisture would depend more critically on infiltration depth for porous materials with steep wetting moisture characteristics; that is, for materials with limited pore-size distributions. The experimental moisture profiles are discussed.

1512* Youngs, E. G.
Water-table Heights in a Drained Homogeneous Soil Overlying an Infinitely Permeable Layer.
J. Soil Sci. 1959, **10,** 101–4.
Drainage investigations in the past have been mostly concerned with soils which are infinitely deep or which overlie impermeable beds, and little attention has been paid to soils which overlie a more permeable layer. Electric-analogue experiments are described which give solutions to the particular case of a homogeneous soil, drained by a uniform system of ideal drain tubes and overlying an infinitely permeable layer, for different ratios of rainfall intensity to hydraulic conductivity and for various depths of the permeable layer below the drain level. The results are presented in terms of a correction factor which, when multiplied by the height of the water table above the drain level midway between the drain lines which would be observed if the topsoil extended to infinite depth with the same ratio of rainfall to hydraulic conductivity, gives the maximum water-table height for a given depth of boundary between the soil and permeable layer below the drain level, expressed as a fraction of the half-spacing of the drains. The correction factor varies with the ratio of rainfall intensity to hydraulic conductivity and the depth of the permeable layer below the drain, approaching unity as this depth increases beyond one-third of the half-spacing of the drains. The correction factor obtained here is compared with that obtained for the case of the soil overlying an impermeable bed for the values of the ratio of rainfall intensity to hydraulic conductivity of 0·01, 0·02, 0·05, and 0·10. The two sets of results represent the extreme cases of water-table heights which can be observed in a two-layered soil with the drain laid in the top layer.

MISCELLANEOUS

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